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RCRA Guidance Document Surface Impoundments Liner Systems Final Cover, and Freeboard Control

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RCRA GUIDANCE DOCUMENT

SURFACE IM NDMENTS

LINER SYSTEMS, FINAL COVER, AND

FREEBOARD CONTROL

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[TO BE USED WITH RCRA REGULATIONS *

SECTIONS 264.221(a) and (c), 264.222(a), and 264.228(a)]

PER 11/19/86, Chaps. E & F ONLY. CHAPS. A-D MADE OBSOLETE BY HSWA, '84, replaced BY THE DOUBLE LINER GUIDANCE, * D-25, in THE RCRA DOCKET.

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16. Abstract (Limit: 200 words)

This guidance document presents surface impoundment design specifications that the EPA believes comply with the design and operating requirements of Section 264.228(a) of surface impoundment regulations. The document is arranged according to the sections of the regulations to which it corresponds. The specifications contained in this document are guidance, not regulations. The Agency is not requiring, and does not intend, that all units be built this way.

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side of added protection. This is prudent, in the Agency's opinion, given the uncertainties associated with prediction of pollutant movement through soils.

Owners and operators choosing to incorporate a leak detection system between a double liner design as a means of qualifying for exemption from the ground-water protection and associated monitoring requirements of Subpart F in accordance with §264.222, must incorporate a secondary liner, under the leak detection system, which meets the containment requirement for liner systems under §264.221(a). For most surface impoundments, this means that a synthetic secondary liner must be used as a minimum. If the impoundment is being designed to operate for more than 30 years, then the synthetic liner should be backed up by a tertiary soil liner meeting the specifications discussed herein. The regulations are written to require prevention of release by the secondary liner in surface impoundments exempted from Subpart F because the owner or operator may choose, upon detection of a leak, to convert his unit to the same status as other surface impoundments installing ground-water monitoring facilities and becoming subject to the ground-water protection standards of Subpart F. Most other surface impoundments must have a liner system capable of preventing migration of liquids.

E. Cap (Final Cover) Design

1. The Regulation

The cap or final cover must be designed to minimize infiltration of precipitation into the surface impoundment after closure. It must be no more permeable than the liner system.

It must operate with minimum maintenance and promote drainage from its surface while minimizing erosion. It must also be designed so that settling and subsidence are accommodated to minimize the potential for disruption of continuity and function of the final cover.

2. Guidance

(a) The cap or final cover should be placed over the surface impoundment after the waste has been solidified and compacted enough to support it. Solidification and fixation processes often take days or weeks to completely stabilize. Final cover should not be applied before stabilization is nearly complete.

(b) The cap (final cover) should consist of the following as a minimum:

(1) A vegetated top cover, as described in paragraph (c) of this section;

(2) A middle drainage layer as described in paragraph (d) of this section; and

(3) A low permeability bottom layer as described in paragraph (e) of this section.

(c) The vegetated top cover should:

(1) Be at least 60 centimeters (24 inches) thick;

(2) Support vegetation that will effectively minimize erosion without need for continuing application of fertilizers, irrigation, or other man-applied materials to ensure viability and persistence (Fertilizers, water, and other materials may be applied during the closure or post-closure period if necessary to establish vegetation or to repair damage.);

(3) Be planted with persistent species that will effectively minimize erosion, and that do not have a root system that will penetrate beyond the vegetative and drainage layer;

(4) Have a final top slope, after allowance for settling and subsidence, of between three and five percent, unless the owner or operator knows that an alternate slope will effectively promote drainage and not subject the closed facility to erosion. For slopes exceeding five percent, the maximum erosion rate should not exceed 2.0 tons/acre using the USDA Universal Soil Loss Equation (USLE); and

(5) Have a surface drainage system capable of conducting run-off across the cap without forming erosion rills and gullies.

(d) The drainage layer should:

(1) Be at least 30 centimeters (12 inches) thick with a saturated hydraulic conductivity not less than 1×10^{-3} cm/sec;

(2) Have a final bottom slope of at least two percent, after allowance for settling and subsidence;

(3) To prevent clogging, be overlain by a graded granular or synthetic fabric filter. Where a granular filter is used, the grain size ratio should meet the following criteria:

$$\frac{\text{D15 (filter soil)}}{\text{D85 (drainage layer)}} < 5$$

$$\frac{\text{D50 (filter soil)}}{\text{D50 (drainage layer)}} < 25$$

and

$$\frac{\text{D15 (filter soil)}}{\text{D15 (drainage layer)}} = 5\text{-}20$$

where:

D15 = grain size, in millimeters, at which 15% of the filter soil used, by weight, is finer;

D85 = grain size, in millimeters, at which 85% of the drainage layer media, by weight, is finer;

D50 = grain size, in millimeters, at which 50% of the filter soil or drainage media, by weight, is finer; and

(4) Be designed so that discharge flows freely in the lateral direction to minimize head on and flow through the low permeability layer.

(e) The low permeability layer should have two components:

(1) The upper component should:

(A) Consist of at least a 20 mil synthetic membrane;

(B) Be protected from damage below and above the membrane by at least 15 centimeters (6 inches) of bedding material no coarser than Unified Soil Classification System (USCS) sand (SP) and which is free of rock, fractured stone, debris, cobbles, rubbish, roots, and sudden changes in grade (slope). The drainage layer and lower soil (clay) component may serve as bedding materials when in direct contact with synthetic caps if they meet the specifications contained herein;

(C) Have a final upper slope (in contact with the bedding material) of at least two percent after allowance for settling; and

(D) Be located wholly below the average depth of frost penetration in the area;

(2) The lower component should:

(A) Include at least 60 centimeters (24 inches) of soil recompacted to the maximum practical extent, but capable, if placed on a firm base, of being recompacted to a saturated hydraulic conductivity of not more than 1 X 10^{-7} cm/sec;

(B) Have the soil emplaced in lifts not exceeding 15 centimeters (6 inches) before compaction to maximize the effectiveness of compaction;

(f) In designing the final cover, owners and operators should estimate and accommodate the amount of settling and subsidence expected as a result of degradation and long-term consolidation of waste.

3. Discussion

The guidance calls for placing the final cover once the waste remaining in the surface impoundment has been solidified through sorption, fixation, or some other means and after it has stabilized and been compacted sufficiently to support the final cover. Some of the fixation processes take days or weeks to stabilize and placement of final cover should not commence until the process is nearly complete.

The Agency believes that a three layer final cover (cap) will adequately minimize infiltration of precipitation, which is the primary purpose of the final cover. The final cover acts to minimize infiltration by causing precipitation to run off through use of slopes, drainage layers, and impermeable and slightly permeable barriers. By minimizing infiltration, the generation of leachate will also be minimized, thereby reducing long-term discharge of pollutants to the ground water

to a bare minimum. To prevent the "bathtub effect," i.e., to prevent the landfill from filling with leachate after closure, the final cover must be no more permeable than the most impermeable component of the liner system (or of the underlying soils). In this way, no more precipitation is allowed to infiltrate into the closed impoundment than can escape through the bottom liner. Prevention of the "bathtub effect" is important to eliminate the possibility of surface overflow or migration through porous surface strata. Other functions of the final cover include prevention of contamination of surface run-off, prevention of wind dispersal of hazardous wastes, and prevention of direct contact with hazardous wastes by people and animals straying onto the site.

The top layer should have at least two feet of soil capable of sustaining plant species which will effectively minimize erosion. Two feet was chosen because it will accommodate the root systems of most nonwoody cover plantings and is typical practice within the waste management industry today. Species planted should not require continuing man-made applications of water or fertilizers to sustain growth since such applications cannot be guaranteed in the long term. Application of water and fertilizer is, of course, acceptable during the early stages of the post-closure care period as the plant growth is being established. The plant species chosen should also not have root systems which can be expected to penetrate beyond the vegetated and drainage layers. If they penetrate deeper, they can damage the integrity of the low permeability layer.

After allowance for settling and subsidence, the final slope should be at least three percent to prevent pooling due to irregularities of the surface and vegetation but less than five percent to prevent excessive erosion. Owners and operators using different final slopes should determine that an alternate slope will not be beset with erosion problems and that it will promote efficient drainage.

The U.S. Department of Agriculture Universal Soil Loss Equation (USLE) is recommended as a tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

$$A = RKLSCP$$

where R = rainfall and run-off erosivity index

K = soil erodibility factor, tons/acre

L = slope-length factor

S = slope-steepness factor

C = cover/management factor

P = practice factor

The data necessary as input to this equation are described in Evaluating Cover Systems for Solid and Hazardous Waste (SW-867), September 1980, U.S. EPA. The maximum rate of erosion for any part of the cover should not exceed 2.0 tons/acre in order to minimize the potential for gully development and future maintenance. The agricultural data base indicates that rates as low as 1/3 ton per acre are achievable for a silt-loam soil, sloped four percent with a blue grass vegetative cover. The Agency believes that two tons per acre is more readily achieved and

does not significantly increase cover maintenance. The top layer should also have some means of conducting runoff (e.g., swales or conduits) to safely pass run-off velocities and volumes without eroding the cover.

The second layer or drainage layer is analogous in function to the leachate collection system over the liner of a landfill. It should be at least 12 inches thick to provide capacity to handle water from major sustained storm events, and should be constructed of porous materials (at least 1×10^{-3} cm/sec hydraulic conductivity). Drainage tiles or other collection devices are not necessary. The Agency believes that the combination of very porous media, a final minimum two percent slope after settling, and the impermeable nature of the layer beneath will effectively conduct precipitation infiltrating the vegetative layer, off of the unit. As with the leak collection system, the drainage layer should be overlain with a graduated granular or synthetic fabric filter to prevent plugging of the porous media with fine earth particles carried down from the vegetated layer. To prevent fluid from backing up into the drainage layer, the discharge at the side should flow freely.

The function of the low permeability layer is to reject fluid transmission, thereby causing infiltrating precipitation to exit through the drainage layer. It should consist of at least two components. The upper component should be at least a 20 mil thick synthetic membrane. While the regulations do not specify that the cap <u>prevent</u> infiltration, the requirement that it be no more permeable than the bottom liner, as a practical

matter, necessitates the use of a synthetic membrane. This is so because the regulatory requirement for the liner system does specify that liquids be contained, and this will be translated, in most cases, into a very nearly impermeable synthetic membrane liner.

The minimum thickness specified for the synthetic component of the final cover (20 mil) is less than that recommended for the liner (30 mil) because (1) the final cover is not expected to come in contact with chemical wastes which will tend to hasten failure, and (2) once placed, the potential for damage is small as compared to the potential for underliner damage where waste is in contact with the liner throughout the operating life of the cell. While intact (30 + years in the absence of damage), the synthetic component will essentially prevent transfer of precipitation through it and leachate production should be very nearly zero. As with underliners, synthetic caps should be protected from from punture and tears by at least six inches of bedding materials with the consistency of sand or finer. In most cases, the drainage layer media above the synthetic cap, together with the soil (clay) liner under it, can effectively function as the bedding material.

Even with protection from damage, the synthetic cap will not last forever. At some point, perhaps in the far distant future, the synthetic membrane will degrade. At that time, the function of minimizing infiltration will fall to the second component, a 2-foot minimum clay soil cap with a maximum hydraulic conductivity of 1×10^{-7} cm/sec. Although some small amount

of precipitation will seep through this secondary cap, the amount of leachate generated will be quite small and escape to the ground water should be mimimal. Unless damaged or affected by differential settling, the secondary soil liner should remain intact and effective for all time. One source of damage is frost heaving which can disrupt the continuity of the impermeable layers. For this reason, the impermeable layer should be placed below the average depth of frost penetration in the area. This may necessitate a thicker cover than would otherwise be necessary.

One of the more difficult problems associated with designing final cover is how to allow for settling and subsidence. Settling occurs as a result of natural compaction and consolidation and biological degradation of organics. It tends to be relatively uniformly distributed and usually occurs shortly after closure. Subsidence is a more difficult problem since it tends to be unevenly distributed, resulting in differential sinking which in turn can cause disruption in continuity of the final cover. It most often occurs as the result of final release of liquids from, and collapse of drums and is, therefore, not normally a major problem with closed surface impoundments. Settling on the other hand, may pose a significant problem if remaining wastes are high in organic content or if organic sorbants (e.g., sawdust or paper) are used to solidify the wastes. Chemical fixation processes are usually inorganic in nature and are not prone to significant settling once stabilization is complete.

EPA intends to develop specific design requirements which will ensure adequate allowance for settling and subsidence. As of this writing, however, the Agency lacks sufficient information to judge the effectiveness of various design options. Therefore, this guidance suggests simply that owners and operators estimate the amount of subsidence and allow for it in the final cover design as best they can. The final result should be a minimum three percent final slope after settling and subsidence. During the postclosure period, the regulations require that the damaging effects of settling and subsidence (e.g., disruption of the continuity and slope of the cap) be repaired. It thus behooves the owner or operator to adequately allow for subsidence and settling. As the Agency evaluates alternative methods of designing final cover to effectively allow for settling and subsidence, it will issue further guidance or perhaps even additional regulations covering the subject.

One suggestion which owners and operators may consider as a means of at least partially accomodating settling and subsidence, is to stage final closure and the placement of the final cover. Unsubstantiated information from the field leads EPA to believe that the most severe subsidence and settling problems occur rather soon after closure. It may be preferable therefore, from both an environmental and cost standpoint, to delay placement of the relatively expensive final cover for six months or more in those cases where substantial subsidence or settling are expected. By so doing, expensive repairs to the final cover may be avoided. This would require an extension in

the 180 day limit to the closure period imposed in Subpart G. In deciding whether to grant such an extension, in accordance with the rules of Subpart G, the permitting official will normally require installation of an expendable interim cover, capable of minimizing precipitation migration into the unit. The Agency solicits information on the effectiveness of this and other approaches to dealing with the settling/subsidence problem.

F. Freeboard Control

1. The Regulations

The regulations require simply that the owner or operator prevent overtopping of his surface impoundment from virtually any eventuality, including normal or abnormal operations, overfilling, wind and wave action, rainfall, equipment malfunctions, and human error.

To implement this requirement, the owner or operator must demonstrate in his permit application that design features and operating procedures at his operation will prevent overtopping. If acceptable to the permitting official, these features and procedures will be incorporated in the permit.

2. Guidance

(a) Where possible, surface impoundments should be designed with outfall mechanisms such as weirs or spillways which are relatively insensitive to inflow.

(b) Where outfalls are sensitive to inflow, i.e., where adjustments must be made to maintain impoundment freeboard as inflow increases, outfall devices (or inflow controls) should be automaticaly controlled by signals from level-sensing instruments.

(c) Except when equipped with inflow insensitive outfalls as described in (a) above, surface impoundments should be equipped with a high-level alarm based on a different level sensor than that used for automatic control.

(d) Surface impoundments should be designed to maintain at least 60 centimeters (two feet) of freeboard unless it is known that normal fluctuations in level and maximum wave action will not cause overtopping.

(e) A surface impoundment should be designed so that any flow of waste into the impoundment can be immediately shut off in the event of overtopping or liner failure.

(f) A surface impoundment should have a run-on control system designed to prevent flow into the impoundment during the peak discharge from a 100-year storm unless the impoundment is designed to accommodate the extra flow without detrimental effects to the impoundment or appreciable loss of freeboard.

3. Discussion

Preventing overtopping of surface impoundments is not normally a difficult engineering problem. Many impoundments are operated on a flow through basis. Typically, these are impoundments used for treatment of wastes; biological oxidation lagoons are a common example, though not one normally associated with hazardous wastes. Frequently, these impoundments are designed with simple spillway or weir-type discharge structures which maintain a constant freeboard level in the impoundment. With this type of arrangement, the sensitivity of freeboard level is dependent directly on the relative width of the spillway or weir.

Normally, but not always, these structures are sufficiently wide so that freeboard level is insensitive to normal changes in flow. In these cases, all that is necessary is the provision of a modest freeboard level sufficient to deal with wave action and with the minor fluctuations which will occur as flow changes. The Agency believes two feet will be sufficient in virtually all cases where discharge structures of this type are used.

Some impoundments are designed with other discharge arrangements. Some, such as circular weirs, operate on the same principle as those discussed above, but because the effective discharge width of the device is often narrow relative to potential flow fluctuations, they may be overwhelmed by abnormal rainfall events or malfunctions in the production equipment which feeds wastes to the impoundment. Other arrangements require adjustment to the discharge structures to maintain freeboard level. A common design of this type incorporates underflow pipes through a dike. Freeboard level in these designs is usually controlled by a valve on the pipe. Others operate off of a sump arrangement with the freeboard level controlled by turning a pump on and off. Storage impoundments are often constructed this way. Some other impoundments, usually those operated as seepage or evaporation impoundments, have no discharge arrangment. Obviously, with no discharge, the freeboard level is very sensitive to substantial changes in inflow to the impoundment.

Where freeboard level is sensitive to flow changes, there are a number of design and operating alternatives which can be

adopted to provide adequate protection against overtopping:

(1) Emergency spillways or overflow piping arrangements can sometimes be provided which can be connected to holding ponds or tanks to contain the overflow. If these latter units are to be used only in the unlikely event of an emergency, they need not be permitted. However, if they are to be used on a statistically predictable recurring basis for surge capacity, permitting is necessary. This will require exercise of some judgment on the part of the permitting official.

(2) Another alternative is to control the discharge device automatically based on freeboard level. The underflow valve can be opened or closed automatically to maintain a set freeboard level through signals from level-sensing instruments. Reliable level sensing devices have been available for many years and are usable in most situations. Discharge pumps can be similarly controlled (turned on and off to maintain level within a range). Where it can be accommodated from the point of view of production or operation of the rest of the facility, it may be possible to automatically control the amount of waste flowing into the impoundment through valves or pumps based on freeboard level.

(3) Outfall devices can also be controlled manually. In these cases, the owner or operator must be prepared to demonstrate that he either maintains sufficient freeboard to accommodate any reasonably possible increase in influent flow or that the combination of the rate of possible flow increases coupled with the frequency of operator inspections to control discharge

will eliminate potential overtopping due to sudden unnoticed increases in level. In these cases, the frequency of control inspections must be specified in the inspection schedule and thus in the permit.

(4) Some impoundments have no discharge devices. In these cases, owners or operators must be able to demonstrate either that the rate of seepage or evaporation is such that overflow is not possible even under maximum possible inflow rates or, more probably, that operating procedures are in effect which will effectively control inflow so that overtopping conditions will not occur. A convincing demonstration should be required in any case.

Of the acceptable options discussed above, the Agency clearly favors automatic controls and/ or provision of foolproof arrangements such as weir discharges or emergency collection devices (tanks or ponds). These are not as sensitive to human error as are those arrangements requiring human inspection and manual operation. Automatic control devices based on level sensors are, however, subject to malfunctions. Because of this, the Agency recommends that any freeboard control arrangement that is sensitive to inflow variations (i.e., all except those using weirs, spillways, or similar devices, or where possible inflow variations cannot cause overflow) be equipped with an alarm to warn of loss of freeboard so emergency action can be taken to prevent overtopping. Typically, these will also be based on a level sensor device, and the Agency recommends that a different sensing unit and different type of device be

used than that used for automatic control. This will help ensure that both do not fail at the same time.

EPA believes that two feet of freeboard will normally provide sufficient protection against overtopping due to inflow fluctuations or wave action. However, where manual operation is involved, freeboard levels substantially greater may be necessary to assure adequate protection. Smaller freeboard levels may be justified if the owner or operator can demonstrate that level variations due to possible flow changes are very small or that the automatic level control response is such that level variations will be very small.

In the event overtopping does occur, in spite of the safeguards built into the system, or in the event of some other catastrophic failure (e.g., dike failure), there must be some way to quickly shut off inflow to the impoundment. The Agency does not care how this is accomplished so long as it can be done quickly and without causing significant environmental or human health problems elsewhere. Possible options might include provision of redundant units or immediate shutdown of production operations feeding the impoundment.

Many ponds and lagoons are designed, either purposefully or circumstantially, to collect run-off from adjacent plant areas or even sometimes from whole watersheds. Depending on the magnitude of rainfall events and the size of the drainage area relative to the impoundment capacity, storm run-off can provide an overwhelming inflow to the impoundment, causing overtopping. Unless it can be shown at the time of permitting

that the impoundment is designed to handle storm water without appreciable loss of freeboard or other detrimental effects on the impoundment, a run-on control system should be installed. The Agency recommends that the capacity of the run-on control system be designed to divert the maximum flow from a 100-year storm event. This is the most severe storm event for which historical meteorologic data is normally available. Choice of this rather stringent storm event indicates the Agency's level of concern over potential overtopping of surface impoundments containing hazardous wastes. This level of concern stems not only from the inherent threat posed by the uncontrolled escape of hazardous wastes into the environment but also from the potential for overtopping to threaten the very stability of the dike itself; leading to a possible complete washout with accompanying catastrophic results. Nevertheless, there are some events, including storm events with greater than a 100 year severity, that separately or in combination can result in overtopping, which must be ignored as a practical matter. Many of these border on the absurd such as the remote possibility of an airplance crash in the impoundment. Others are improbable combinations of events such as the possibility that all liquid containing storage tanks in a manufacturing operation will break at once, releasing their contents to the sewer system feeding the impoundment, causing it to overflow. EPA does intend such events to be protected against. Judgement must be exercised during the permit process in dealing with the more remote possibilities.